REPLACED BY
ART 34 AMDT

5(PRTS

PCT/JP02/08951
10/508769
DT04 Rec'd PCT/PTO 22 SEP 2004

PATENT SPECIFICATION

TITANIUM-MADE PLATE-TYPE HEAT EXCHANGER AND PRODUCTION METHOD THEREOF

[Field of the Invention]

The present invention relates to a titanium-made plate-type heat exchanger and production method thereof.

[Related Art]

A conventional titanium-made plate-type heat exchanger is disclosed in Japanese laid open patent No.2002-35929. In the heat exchanger by this invention, herringbone patterned titanium plates are layered such that herringbone patterns of the neighboring plates are arranged in opposite directions each other, and first-fluid flow paths and second-fluid flow paths formed by gaps between the two neighboring plates are alternately arranged so that heat is exchanged between the two fluids.

The above-mentioned heat exchanger is produced according to the following steps: positions to be connected on respective herringbone plates are coated with or filled by a brazing solder; the coated or filled plates are placed in a vacuum heating furnace and the plates are degassed as reducing the pressure of the furnace and gradually raising the temperature of the furnace; and after a required reduced pressure is attained, coated or filled positions are brazed by heating the plates over 850℃.

However, the conventional titanium-made plate-type heat exchanger has the following problems.

(1) Since herringbone patterns are formed by concave strips with a chevroned cross section, two neighboring plates are contacted on concave edge points of respective concave strips crossing each other. Consequently, connected positions by the brazing solder show a point to point connection pattern so that a connected strength between the neighboring plates is low. As a result, a pressure-resistant performance of the flow paths of the heat

exchanger is not so good.

(2) Since a heat transfer area of fluid flow paths formed by the two herringbone plates corresponds to surface areas of the herringbone plates, a heat transfer area per unit volume of the heat exchanger is not so large. Consequently, a heat radiating performance of the flow paths is not so good.

(3) When the plates are brazed at a temperature more than the transformation temperature (882℃) of α-titanium, the herringbone plates are deteriorated, which means a durability of the heat exchanger is deteriorated.

And in producing the conventional titanium-made plate-type heat exchanger, since the herringbone plates are brazed over 850℃, they are deteriorated. Because when the brazing solder is heated over 850℃, sometimes the titanium-made plates are heated over the transformation temperature (882℃) of α-titanium so that these plates are deteriorated.

The present invention is carried out in order to solve the problems mentioned above, and provides:

(1) A titanium-made plate-type heat exchanger having fluid flow paths with a pressure resistant performance, an excellent heat radiating performance and an excellent durability;

(2) A method to produce a titanium-made plate-type heat exchanger capable of preventing titanium members constituting the fluid flow path from deteriorating due to over-heating.

[Disclosure of the Invention]

A titanium-made plate-type heat exchanger provided by the present invention in which flow paths of a first fluid and a second fluid are alternately arranged such that heat can be exchanged between the two fluids and respective flow paths are formed by connecting titanium plates; the heat exchanger comprises a flat container having an inlet of one of the fluids formed on one end and an outlet of the fluid formed on the other end; an offset-type titanium plate fin connected to the titanium plates on its both

sides and accommodated in the flat container between the inlet and the outlet, wherein: the titanium plate fin and the titanium plates are connected by a Ti-Zr type brazing solder, which melts under 880℃, containing 20 to 40 wt.% of titanium and 20 to 40 wt.% of zirconium (hereinafter referred as “heat exchanger”).

And a production method of a titanium-made plate-type heat exchanger provided by the present invention in which flow paths of a first fluid and flow paths of a second fluid are alternately arranged such that heat can be exchanged between the two fluids, wherein the production method for forming the flow paths by connecting constituting titanium members of the heat exchanger comprises steps of: coating a Ti-Zr type brazing solder, which melts under 880℃, containing 20 to 40 wt.% of titanium and 20 to 40 wt.% of zirconium, over positions to be connected of said constituting members; and heating said brazing solder coated constituting members under 880℃ in an vacuum and/or inert gas atmosphere (hereinafter referred as “production method of heat exchanger”).

In the heat exchanger by the present invention, since top ends of parallel concave strips constituting a pattern of the titanium plate fin constitute a plane which contacts the titanium plate in a plane to plane relation, the titanium plate fin and the titanium are connected by the brazing solder in the form of the plane to plane connection. Consequently, a connected area between the titanium plate and the titanium plate fin is enlarged so that a connected strength is raised.

In the titanium plate fin, the concave strips constituting the pattern of the titanium plate fin show an offset arrangement. Namely, both walls of the concave strip T having a trapezoidal cross section are bent inside with a predetermined pitch. Consequently, a surface area of the titanium plate fin is enlarged so that a heat transfer area of the heat exchanger per unit area is raised.

Further, since a connection between the titanium plates and a connection between the titanium plate and the titanium plate fin are attained

by using the brazing solder which melts under 880℃, namely under the transformation temperature (882℃) of α-titanium, the above-mentioned titanium plates to be connected are not heated over 880℃. As a result, both titanium plates are not deteriorated due to over-heating.

And in the production method of the heat exchanger by the present invention, since the connection between the titanium plates and the connection between the titanium plate and the titanium plate fin are attained by using the brazing solder which melts under 880℃, the above-mentioned titanium plates to be connected are not heated at the transformation temperature of α-titanium, when brazed. As a result, the production method by the present invention can prevent both titanium plates from being deteriorated due to over-heating.

[Brief Description of the Drawings]

FIG.1 is a perspective view schematically illustrating an arrangement of a preferred embodiment of the titanium-made plate-type heat exchanger by the present invention.

FIG.2 is an exploded perspective view of the titanium-made plate-type heat exchanger shown in FIG.1.

FIG.3 is a perspective view of the titanium-made plate-type heat exchanger in FIG.2 viewed from the opposite direction.

FIG.4A is a plan view of first unit plate and FIG.4B is a plan view of the second unit plate in FIG.3.

FIG.5 is a perspective view illustrating main portions of titanium plate fins in FIG.4.

[Best Preferred Embodiments by the Present Invention]

Hereinafter the embodiment by the present invention is explained as referring to drawings.

FIG.1 is a view schematically illustrating the arrangement of the titanium-made plate-type heat exchangers (hereinafter referred as "heat

exchanger") by the embodiment.

As shown in FIG.1, flow paths B, D and F for a first fluid X and flow paths A, C, E and G for a second fluid Y are alternately arranged so that heat is exchanged between the two fluids X and Y.

The first fluid X flows into the flow paths B, D and F from respective inlets 1 and flows out from respective outlets 2. The second fluid Y flows into the flow paths A, C, E and G from respective inlets 3 and flows out from respective outlets 4.

A reference numeral "5" is passages for the fluid X arranged in the flow paths A, C and E and communicated with the inlets 1. A reference numeral "6" is passages for the fluid X arranged in the flow paths A, C and E and communicated with outlets 2.

A reference numeral "7" is passages for the fluid Y arranged in the flow paths B, D and F and communicated with the inlets 3. A reference numeral "8" is passages for the fluid Y arranged in the flow paths B, D and F. Reference numerals "9" and "10" are shut-off paths arranged in the flow path G.

FIGs.2 and 3 are exploded views of the heat exchanger by the embodiment.

As shown in FIGs.2 and 3, the heat exchanger is constituted in the following manner. First unit plates (hereinafter referred as "first unit") U_1 and second unit plates (hereinafter referred as "second unit") U_2 are alternately layered and connected each other. Bosses 11, 12, 13 and 14 are attached to the front end second unit U_2 and a cover plate P is attached to the back end second unit U_2.

As shown in FIGs.4A and 4B, the first and second units U_1 and U_2 are respectively constituted by titanium plates 15 having upright peripheral walls 15a around, titanium guide plates 16, 16 arranged at both longitudinal ends of the titanium plates and two titanium plate fins 17 arranged between the titanium guide plates 16, 16.

Two holes 18 are arranged at each end of the titanium plate 15 so that four holes 18 are symmetrically arranged on both ends of the titanium plate.

A circular hole 19 and a U-shaped cut-out hole 20 are arranged in the titanium guide plate 16. The titanium guide plate 16 is a plate for guiding the fluids and has the same thickness as the titanium plate fin 17. The holes 19 and 20 in the titanium guide plate 16 on the titanium plate 15 of the first unit U_1 and second unit U_2 are arranged in opposite directions.

The circular hole 19 and the U-shaped cut-out hole 20 are respectively communicated with the holes 18.

Mutually communicated holes 18 and 19 constitute the passage (passages 5-8 in FIG.1) communicating two neighboring flow paths, when the first and second units U_1 and U_2 are layered.

And the hole 18 and the cut-out hole 20 mutually communicated each other constitute the inlet (inlets 1 and 3 in FIG.1) to the flow path of the fluid or the outlet (outlets 2 and 4 in FIG.1) from the flow path, when the first and second units U_1 and U_2 are layered.

FIG.5 shows a detailed arrangement of a concave strip T which forms parallel wave-shaped pattern of the titanium plate fin 17 shown in FIG.4. The concave strip T shows an offset arrangement. Namely, pairs of slits are formed with a predetermined pitch from top portions of the both walls 17a of the concave strip T having a trapezoidal cross section to a base plate 17b and portions formed by pairs of the slits are bent inside. The top end of the concave strip T forms a plane.

The flow paths A, C and E in FIG.1 are formed between the second unit U_2 and the titanium plate 15 of the first unit U_1 placed on the second unit and connected each other by the brazing solder, which can be understood when FIG.1 is compared with FIGs.2 and 3.

The flow paths B, D and F are formed between the first units U_1 and the titanium plates 15 of the second units U_2 placed on the first units and connected each other by the brazing solder. The flow path G is formed between the second unit U_2 and the cover plate P covered over the second unit and brazed.

The neighboring titanium plates 15 are connected via the peripheral

walls 15a of the respective titanium plates. The titanium plate fin 17 is connected with the titanium plate 15 via top end of the concave strip T. The both sides of the titanium guide plate 16 are connected to the titanium plates 15. The above-mentioned respective connected portions are connected in the form of plane to plane connection.

The holes 18 of the titanium plate 15 and the holes 19 of the titanium guide plate 16, which form passages (the passages 5 to 8 in FIG.1) for the fluids, are connected via peripheral portions of the respective holes.

The heat exchanger by the embodiment is produced in the following manner.

(1) A brazing solder is coated on the portions to be connected of the first units U_1, second units U_2, the cover plate P and the bosses 11 to 14, and then coated members with the brazing solder are assembled so that a heat exchanger assembly is prepared.

For example, one of the brazing solders shown in TAB.1, which melt under 880℃, is used as a brazing solder.

TAB.1

Product #	Composition (wt.%)				Melting Point (℃)
	Ti	Zr	Cu	Ni	
No.1	37.5	37.5	25	0	820 – 840
No.2	37.5	37.5	15	10	810 – 830

Since the products in TAB.1 have high hardness and very low malleability, they can not be obtained in the form of a plate or a bar. Consequently, in order to employ the products as a brazing solder, they are atomized in argon gas atmosphere to obtain powdered products, which are mixed with a neutral binder to obtain a paste, which is supplied as the brazing solder to portions to be connected by utilizing a paste supply machine.

(2) Then the prepared heat exchanger assembly is placed in a vacuum heating furnace and heated gradually after the pressure in the furnace is

reduced to around 10^{-4}torr.

The pressure in the furnace is not necessarily reduced to a lower level, but it can be acceptable more than 10^{-4}torr. In stead of the reduced pressure, an inert gas atmosphere by Ar or He gas can be employed, or the inert gas atmosphere under the reduced pressure can be also employed.

(3) When a temperature in the furnace is raised up to 830℃ to 880℃, the furnace is kept at the raised temperature for ca. 30 min. And the temperature in the furnace is lowered afterward.

[Possibilities for Industrial Use]

As explained above, the pressure resistant performance of flow paths is improved in the heat exchanger by the present invention, since the titanium plate and titanium plate fin are connected by the brazing solder in the form of plane to plane connection.

Since the titanium plate fin has the offset arrangement, the surface area of the titanium fin plate is enlarged, namely, a heat transfer area between the fluids is enlarged so that the heat radiation performance of the heat exchanger is enhanced.

Further, since the brazing solder with a melting point lower than 880℃ is employed to connect titanium members which are not heated at a high temperature, the connected titanium members of the heat exchanger are not deteriorated so that durability of the heat exchanger is improved.

And according to the production method of the heat exchanger by the present invention, since the brazing solder having a melting point lower than 880℃ to connect titanium members is employed, the production method can prevent the titanium members from deterioration caused by over-heating.

CLAIMS

1. A titanium-made plate-type heat exchanger in which flow paths of a first fluid and flow paths of a second fluid alternately arranged such that heat can be exchanged between the two fluids, wherein said respective flow paths are formed by connecting titanium plates, comprising:

a flat container having an inlet of one of the fluids formed on one end and an outlet of the fluid formed on the other end; and

an offset-type titanium plate fin connected to said titanium plates on its both sides and accommodated in said flat container between said inlet and said outlet, wherein:

said titanium plate fin and said titanium plates are connected by a Ti-Zr type brazing solder, which melts under 880℃, containing 20 to 40 wt.% of titanium and 20 to 40 wt.% of zirconium.

2. A production method of a titanium-made plate-type heat exchanger comprising flow paths of a first fluid and flow paths of a second fluid alternately arranged such that heat can be exchanged between the two fluids, wherein said production method for forming said flow paths by connecting constituting titanium members of the heat exchanger comprising steps of :

coating a Ti-Zr type brazing solder, which melts under 880℃, containing 20 to 40 wt.% of titanium and 20 to 40 wt.% of zirconium, over positions to be connected of said constituting members; and

heating said brazing solder coated constituting members under 880℃ in an vacuum and/or inert gas atmosphere.